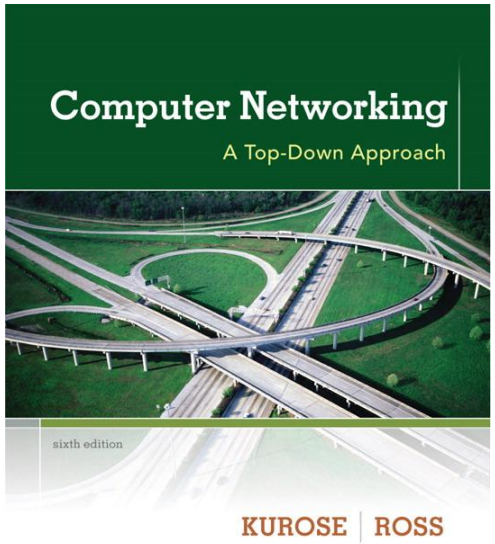
Chapter 4
Network Layer



Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
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Chapter 4: network layer

chapter goals:

- understand principles behind network layer services:
  - network layer service models
  - forwarding versus routing
  - how a router works
  - routing (path selection)
  - broadcast, multicast
- instantiation, implementation in the Internet

Chapter 4: outline

4.1 introduction

4.2 virtual circuit and datagram networks

4.3 what's inside a router

4.4 IP: Internet Protocol

- datagram format
- IPv4 addressing
- ICMP
- IPv6

4.5 routing algorithms

- link state
- distance vector
- hierarchical routing

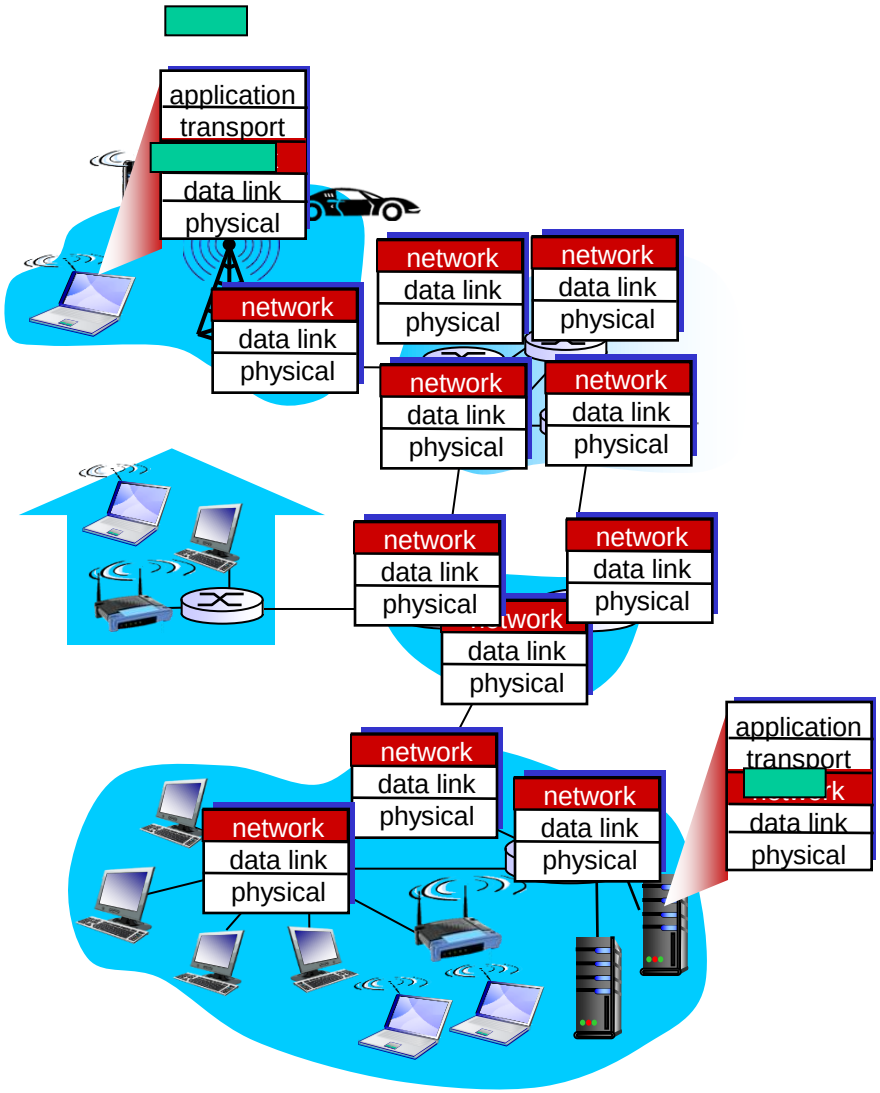
4.6 routing in the Internet

- RIP
- OSPF
- BGP

4.7 broadcast and multicast routing

Network layer

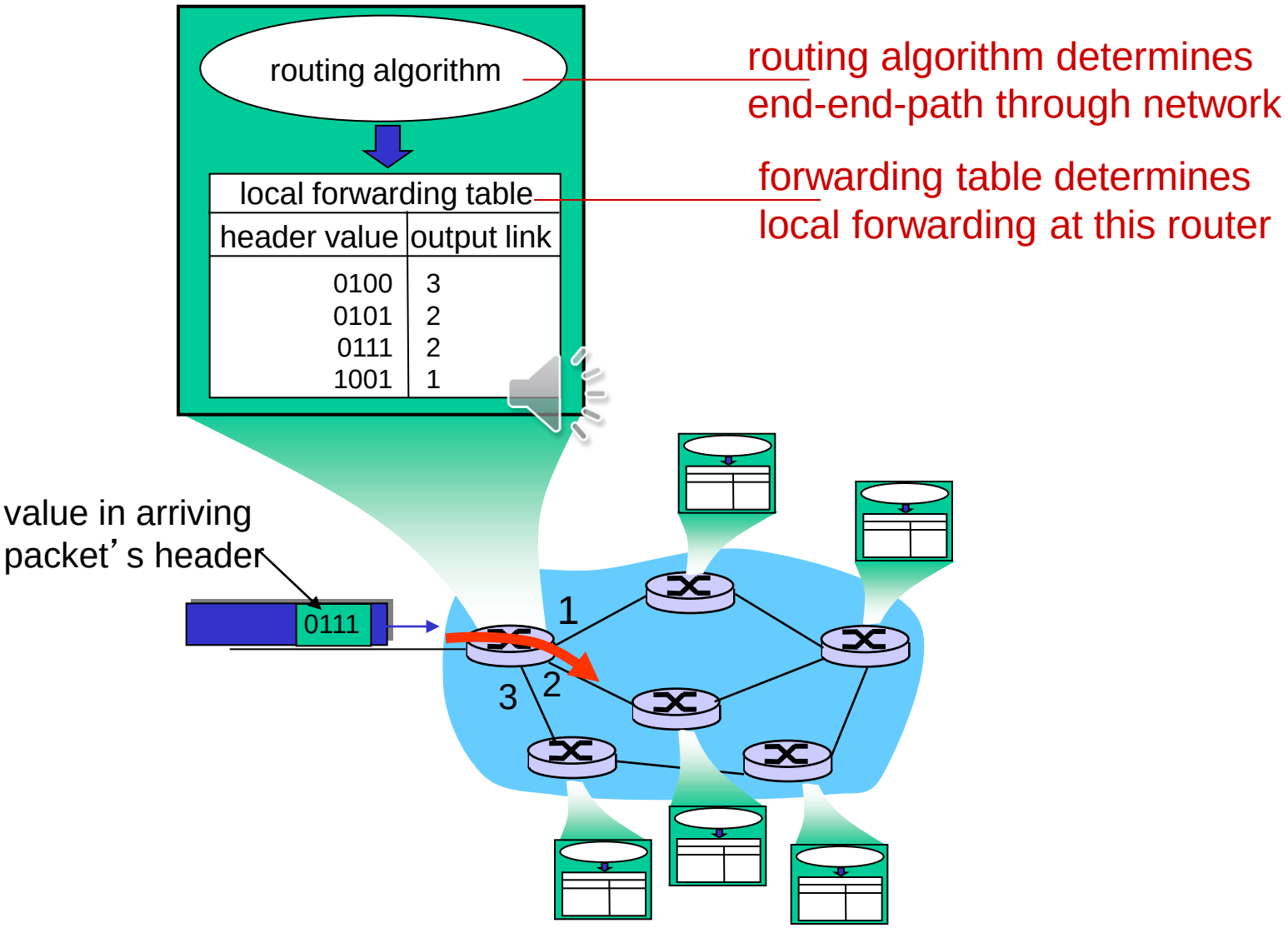
- transport segment from sending to receiving host
- on sending side encapsulates segments into datagrams
- on receiving side, delivers segments to transport layer
- network layer protocols in *every* host, router
- router examines header fields in all IP datagrams passing through it



Three key network-layer functions

- *forwarding:* move packets from router's input *link* to appropriate router output *link*
- *routing:* determine route taken by packets from source to dest.
  - The algorithms that calculate these paths
  - are referred to as **routing algorithms**
- connection setup

Interplay between routing and forwarding



Connection setup

- 3rd important function in *some* network architectures:
  - ATM, frame relay, X.25
- before datagram's flow, two end hosts *and* intervening routers establish virtual connection routers get involved , *this process is referred to as connection setup*

- network vs transport layer connection service:
  - *network:* between two hosts (may also involve intervening routers in case of VCs)
  - *transport:* between two processes

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Connection, connection-less service

- *datagram* network provides network-layer *connectionless* service
- *virtual-circuit* network provides network-layer *connection* service
- analogous to TCP/UDP connecton-oriented / connectionless transport-layer services, but:
  - *service:* host-to-host
  - *no choice:* network provides one or the other
  - *implementation:* in network core

Virtual circuits

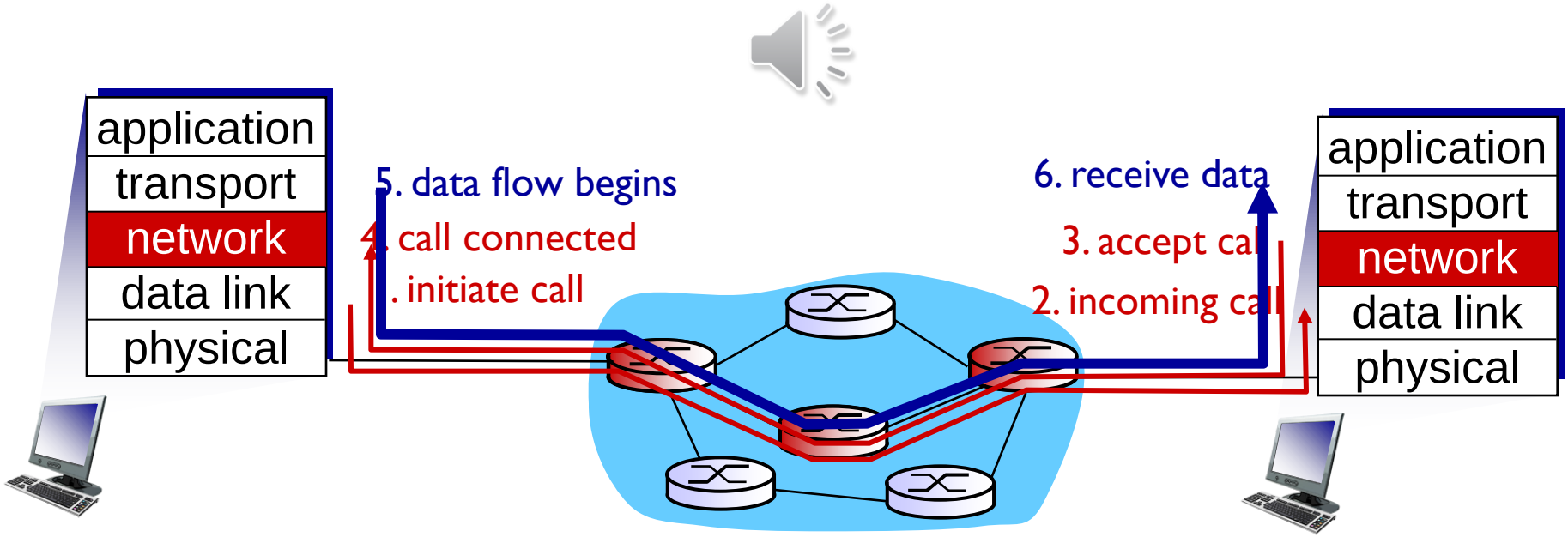
"source-to-dest path behaves much like telephone circuit"

- performance-wise
- network actions along source-to-dest path

- call setup, for each call *before* data can flow
- each packet carries VC identifier (not destination host address)
- *every* router on source-dest path maintains "state" for each passing connection
- link, router resources (bandwidth, buffers) may be *allocated* to VC (dedicated resources = predictable service)

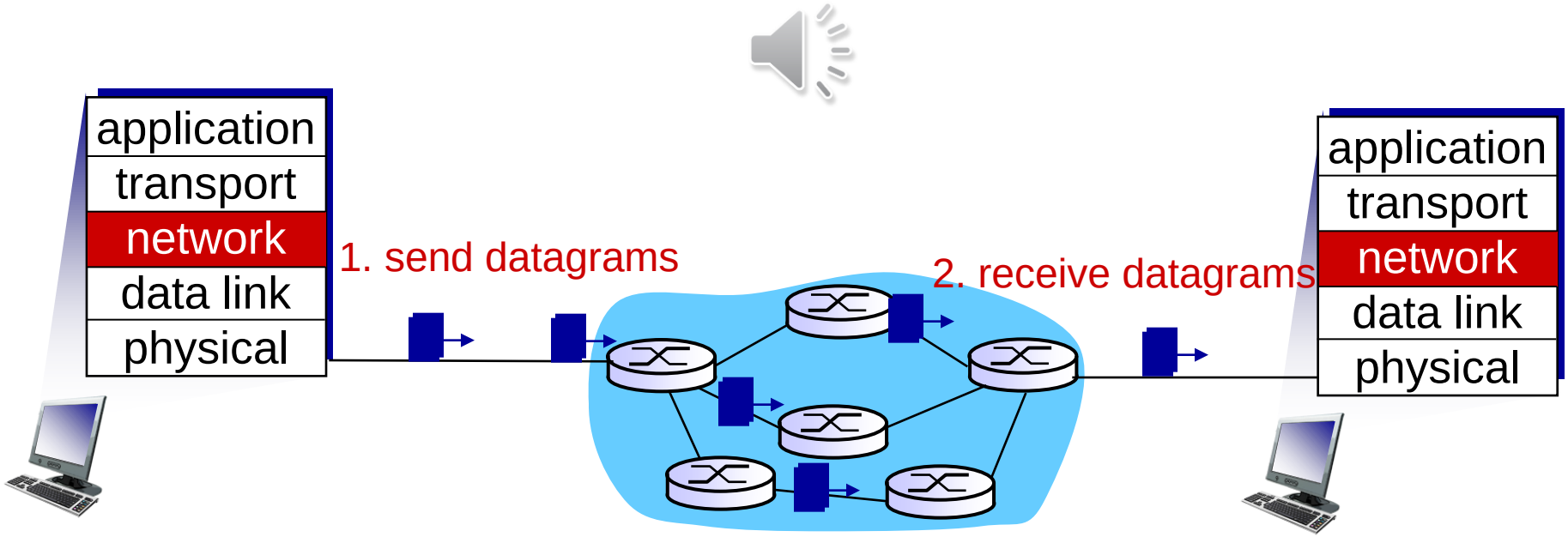
Virtual circuits: signaling protocols

- used in ATM, frame-relay, X.25
- not used in today's Internet

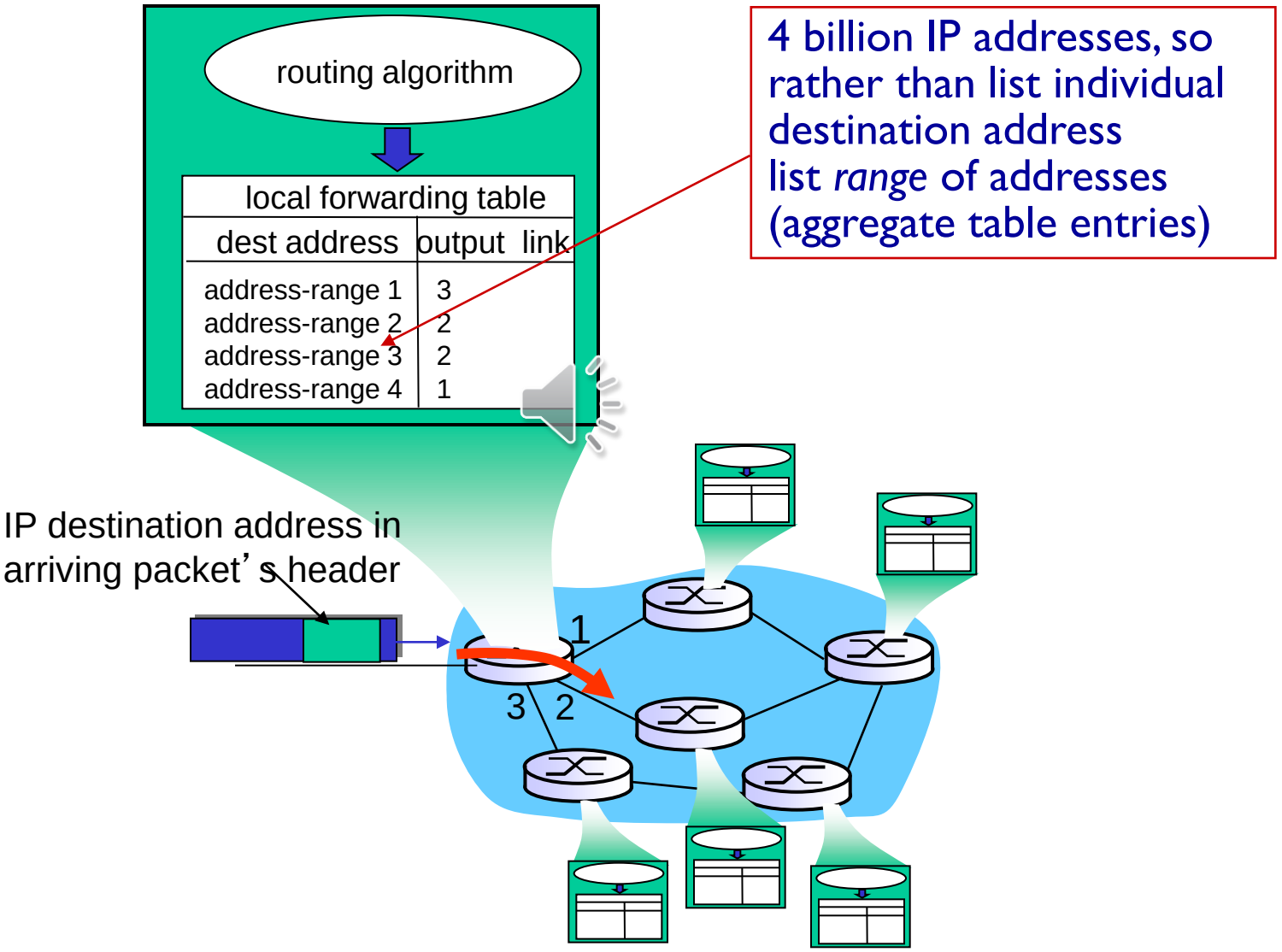


Datagram networks

- no call setup at network layer
- routers: no state about end-to-end connections
- packets forwarded using destination host address



Datagram forwarding table



Datagram or VC network: why?

Internet (datagram)

- data exchange among computers
  - "elastic" service, no strict timing req.
- "smart" end systems (computers)
  - can adapt, perform control, error recovery
  - ***simple inside network, complexity at "edge"***

ATM (VC)

- evolved from telephony
- human conversation:
  - strict timing, reliability requirements
  - need for guaranteed service
- "dumb" end systems
  - telephones
  - ***complexity inside network***

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Router architecture overview

two key router functions:

- run routing algorithms/protocol (RIP, OSPF, BGP)

- *forwarding* datagrams from incoming to outgoing link

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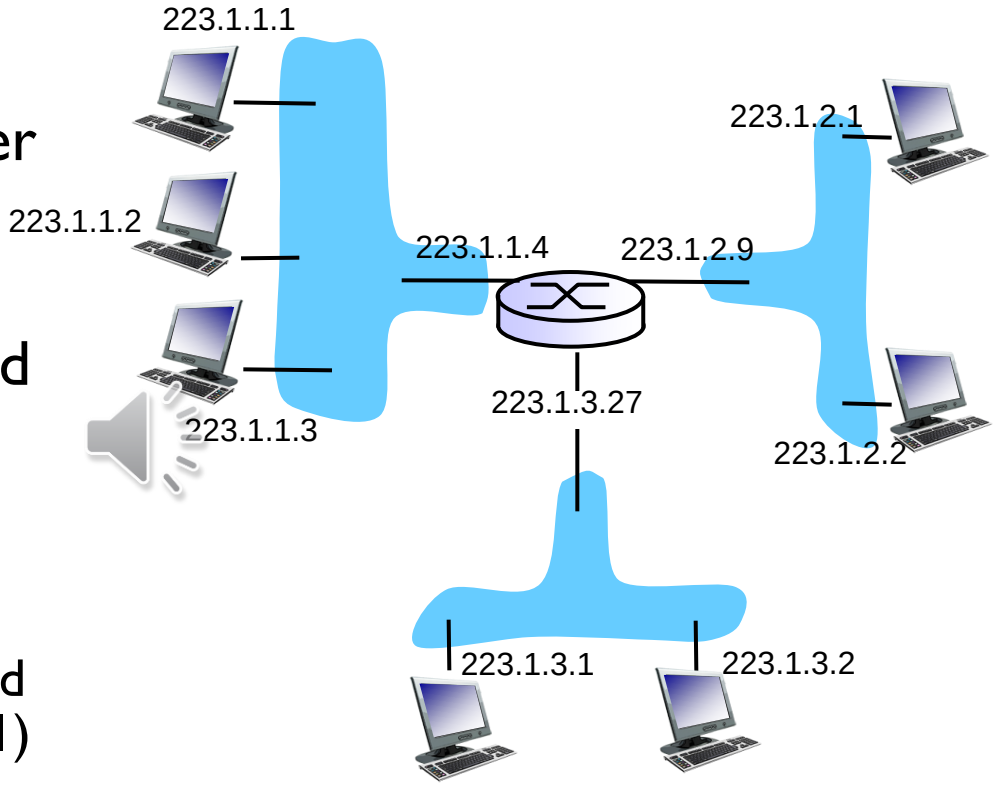
IP addressing: introduction

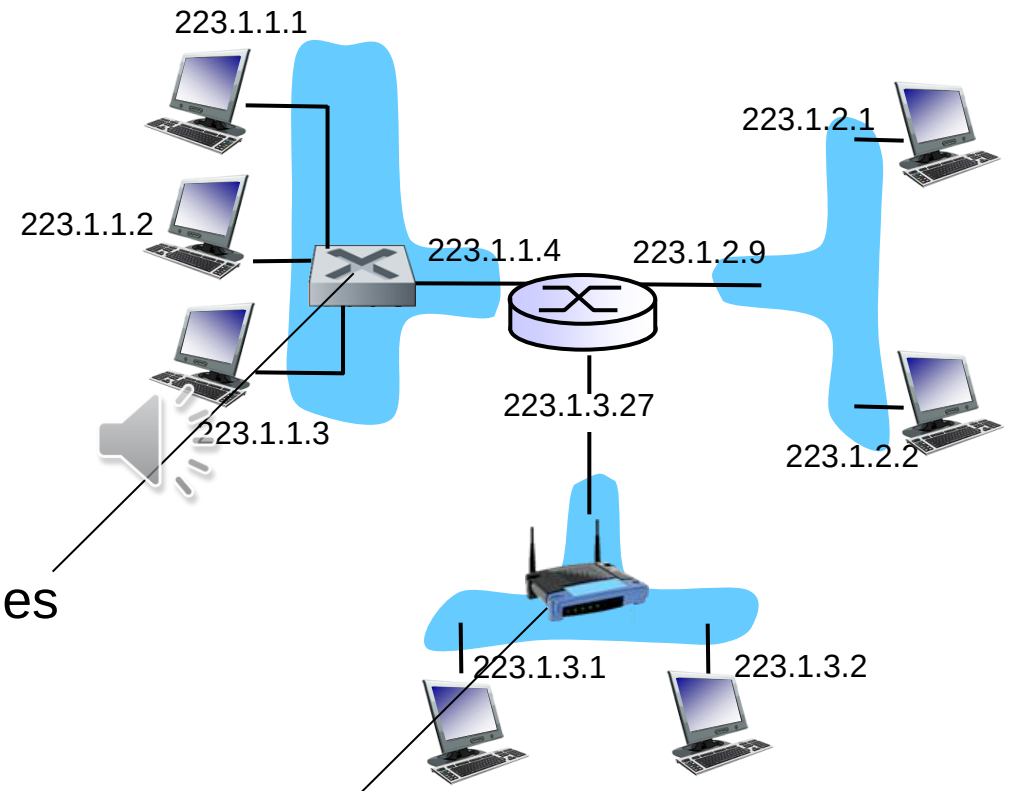
- *IP address:* 32-bit identifier for host, router *interface*
- *interface:* connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has one or two interfaces (e.g., wired Ethernet, wireless 802.11)
- *IP addresses associated with each interface*



223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing: introduction

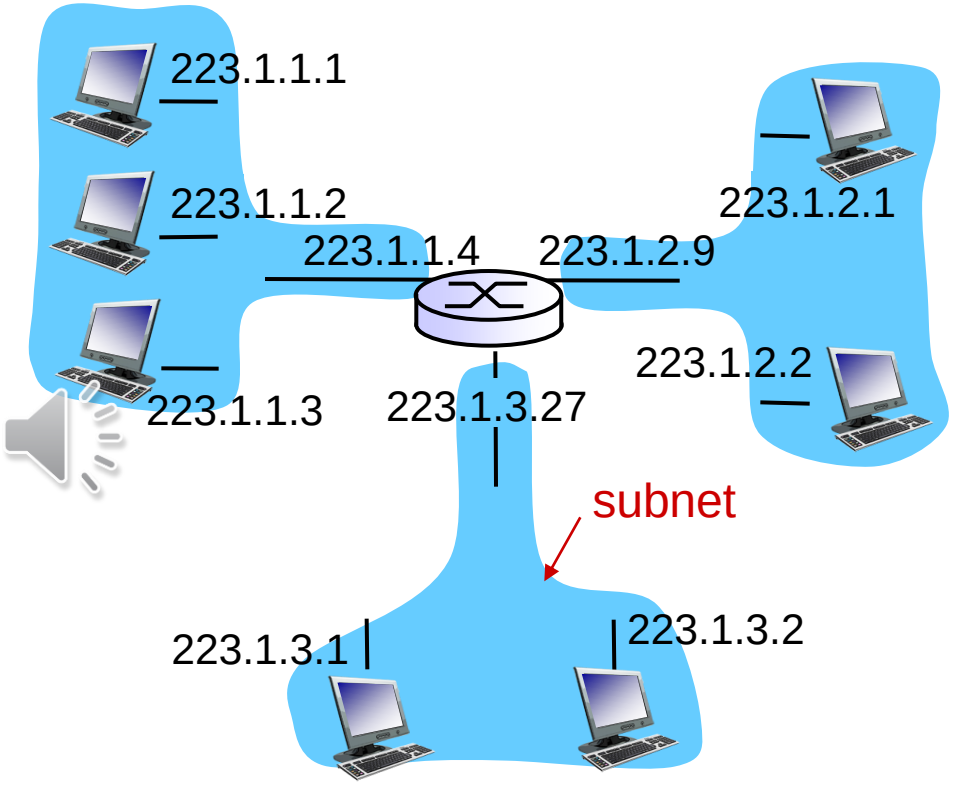


A: wired Ethernet interfaces connected by Ethernet switches

b: wireless WiFi interfaces connected by WiFi base station

Subnets

- IP address:
  - subnet part - high order bits
  - host part - low order bits
- *what's a subnet ?*
  - device interfaces with same subnet part of IP address

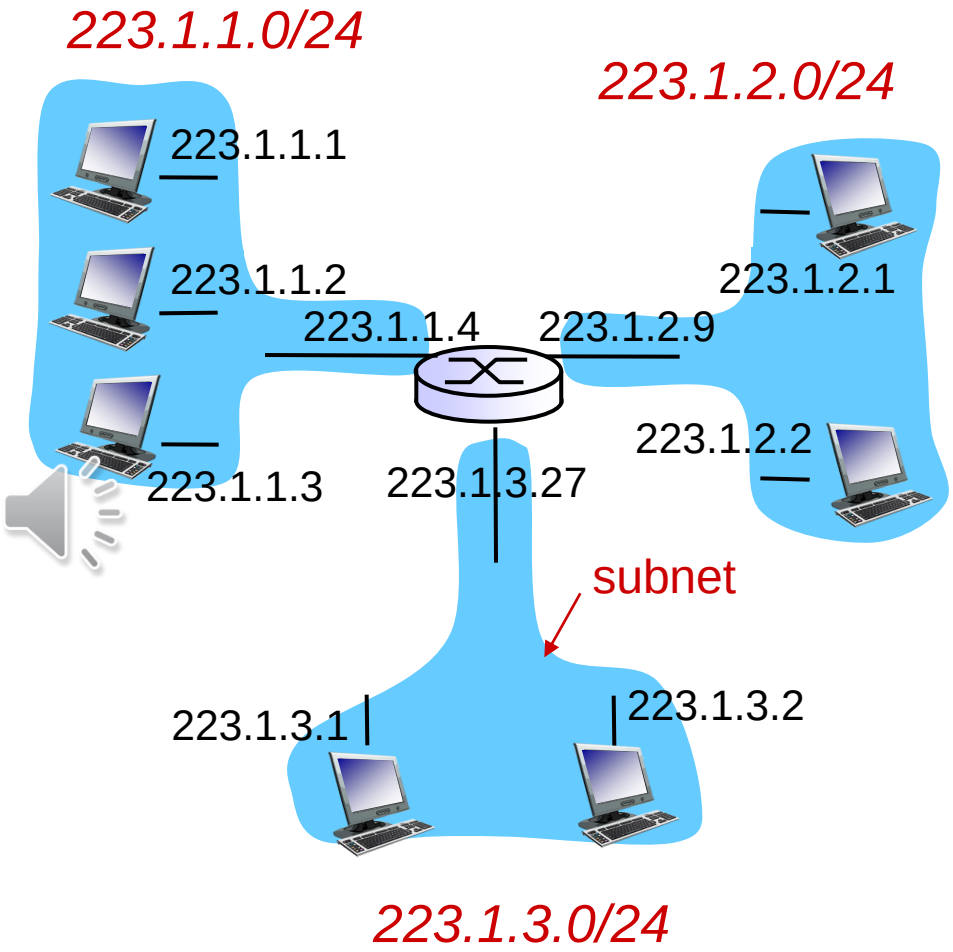


network consisting of 3 subnets

Subnets

recipe

- to determine the subnets, detach each interface from its host or router, creating islands of isolated networks
- each isolated network is called a *subnet*



subnet mask: /24

Subnets

how many?